Mid-term Project Problems

On Friday, March 8, we will not have a formal class. Instead you will work *one* of the problems below and turn in a 1-2 page, single spaced report as described below. You may use either Microsoft Excel or Maple V to obtain your solution. Your project is due in Andrew Green's mailbox in the Physics Department main office by 5 p.m. on Friday, March 8.

Your project is worth 20% of your overall course grade and will be graded on a 10 point scale. The table outlines what you should turn in.

What to Submit	Point Value
1-2 page report	6
graph(s) of your solution(s)	2
copy of your Maple session **or** the first page of your Excel spreadsheet (no data please)	2

Your report should include the following information:

What Report Should Include
Introduction: Description of problem and what you will solve for
Solution Method: Explanation of your method of solution. Explain how you designed your Excel spreadsheet or Maple session. For Excel, specify the formula for the algorithm you used.
Checks on Solution: Explanation of two methods you used to check your solution and why you believe your solution is correct
Conclusions: State what you conclude from your solution of the problem and address the questions asked in the problems

If you have any questions or difficulties, we will be available in B54 of Physics (our usual meeeting place) from 2 to 5 p.m on Friday, March 8 to answer questions.

Problems (work any one of the following)

(1) Olympic Long Jump: During the 1968 Olympic Games in Mexico City, R. Beamon of the United States set a world record of 29 feet 2.5 inches in the long jump, improving the previous world record by over 2.5 feet. Many critics attributed this to the thinness of the air in Mexico City. If one writes Newton's Second Law assuming the air resistance is proportional to the *square* of the jumper's velocity, one gets the following equations:

$$m\frac{dv_x}{dt} = -rkv_x\sqrt{v_x^2 + v_y^2}$$
$$m\frac{dv_y}{dt} = -mg - rkv_y\sqrt{v_x^2 + v_y^2}$$

where v_x and v_y are the x and y components of the jumper's velocity, r is the air density, k is the drag constant, and m is the jumper's mass. Solve the above coupled equations numerically for the following parameter values: v_x*=9.45 m/s*, v_y*=4.15 m/s*, *k=0.182*, r *=0.984 kg/m*^{3} (for Mexico City), *m=80 kg* (approximate mass of R. Beamon). What is the range of Beamon's jump in this model? Is it close to the actual value?

(2) Heat Loss: Consider a mass m of water of specific heat c that is at a uniform temperature T. Suppose the water cools primarily by radiating heat to the surrounding environment which is at constant temperature T_1. The water's loss of heat energy is given by

$$mc\frac{dT}{dt} = -A(T^4 - T_1^4)$$

Solve this equation numerically assuming the values *m=1 kg, A=6´10*$^{-8}$ *W/m*^{2}*K*^{4}, *c=4.18´10*^{3} *J/kgK*, T_1*=290,T(0)=350.* Approximately how long does it take for the water's temperature to fall to 50% of its original value? By what factor does doubling the mass m change the previous cooling time?

(3) Gas Ionization: In a certain gas, ionization occurs at a constant rate A and recombination of the positive ions and electrons occurs at a rate equal to kn^2, where k is called the constant of recombination, and $n(t)$ is the number of ions at time t. In this model the total ionization rate is given by

$$\frac{dn}{dt} = A - kn^2$$

Assuming the values $A=10^5$, $k=5\times10^{-6}$, and $n(0)=0$ (initially no gas is ionized) solve the above equation. How many time units does it take for the gas to become 50% ionized? What effect does changing A and k have on your result?